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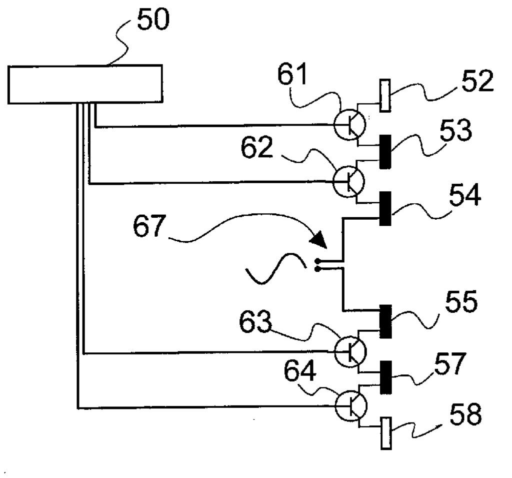

Fig. 3

(57) **Abstract**: The present invention is directed to a living-being proximity sensing arrangement for a vehicle. The arrangement is arranged for distinguishing proximity of a human or animal body from proximity of a non-living object, and comprises a sensor unit including an antenna array, wherein the antenna array is operable in a plurality of operational modes for enabling use of said antenna array for performing at least one of a plurality of different electrical sensing techniques in each of said modes. The antenna array comprises means for providing an antenna input signal to said antenna array and means for presenting an antenna output signal from said antenna array, a plurality of patches spanning a first detection area of the antenna, and a plurality of interconnections between said patches. These interconnections are switchable for enabling connection and disconnection of said switchable electrical connections between said patches for enabling operation of said antenna in each of said plurality of operational modes.

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Title: Living being proximity sensing arrangement for a vehicle, and vehicle equipped therewith.

Field of the Invention

Living being proximity sensing arrangement for a vehicle, said arrangement being arranged for distinguishing proximity of a human or animal body from proximity of a non-living object, wherein said sensor arrangement comprises a sensor unit which comprises an antenna array.

Background

A known drawback of vehicle mirrors, which drawback poses a serious and known traffic hazard, is caused by the fact that vehicle mirrors have a limited viewing angle which provides a blind spot to the driver of the vehicle. This problem is in particular acknowledged for trucks as a result of their length. When a truck makes a right turn (in countries where traffic drives on the right side of the road) or left turn (in countries where traffic drives on the left side of the road), traffic accidents involving pedestrians or small traffic such as bicycles, mopeds and the like may occur as a result of the driver overlooking this traffic due to poor visibility thereof in his mirror. A pedestrian is easily hit by the side of a truck when overlooked by the driver of the truck making a right turn. The results are often disastrous in view of the difference in mass between light traffic such as mopeds or cyclists and trucks, but also in view of the robustness of a truck versus the vulnerability of a pedestrian, cyclist or moped driver).

This problem is acknowledged by society and many solutions have been presented varying from structural modifications to the side of the truck to additional mirrors installed on the truck. One particular area of solutions is directed to the installation of object-proximity-sensing arrangements on a vehicle. These sensing arrangements may for example detect the proximity of an object near the vehicle, giving the driver information on potential risks or hazards.

A drawback of a regular object proximity sensing arrangement is the fact that it does not provide any information on the type of objects, nor on the size thereof. Many proximity sensing arrangements do provide information on the distance between the sensor and the object, however it remains unknown to the driver whether the object is located in a dangerous position in respect of the vehicle's movements or location.

Summary of the invention

It is an object of the present invention to provide a proximity sensing arrangement or a vehicle which is capable of distinguishing the proximity of a human or animal body from the proximity of a non-living object. Moreover, it is an object of the present invention to provide such a sensing arrangement having a straightforward design enabling easy installation on a vehicle. Moreover, it is an object of the present invention to provide a proximity sensing arrangement as mentioned above which is accurate and reliable.

These and other objects are achieved by the present invention in that there is provided a living-being proximity sensing arrangement for a vehicle, said arrangement being arranged for distinguishing proximity of a human or animal body from proximity of a non-living object, said sensor arrangement comprising a sensor unit which comprises an antenna array, wherein said antenna array is operable in a plurality of operational modes for enabling use of said antenna array for performing at least one of a plurality of different electrical sensing techniques in each of said modes, wherein said antenna array comprises: means for providing an antenna input signal to said antenna array and means for presenting an antenna output signal from said antenna array; a plurality of patches spanning a first detection area of said antenna; and a plurality of interconnections between said patches, wherein said interconnections are switchable for enabling connection and disconnection of said switchable electrical connections between said patches for enabling operation of said antenna in each of said plurality of operational modes.

The proximity sensing arrangement according to the present invention comprises an antenna array which is designed such that it can be used for performing a plurality of different types of electrical based sensing techniques for which different types of antenna designs are to be applied. The antenna array used in the sensing arrangement according to the present invention is made up of a plurality of patches that may be dynamically interconnected by opening or closing switchable interconnections between these patches and thereby dynamically amending the geometric layout of the antenna such as to adapt it to a current electrical sensing technique applied in a certain operational mode. In particular, by selecting specific patches to be active in specific operational modes, the antenna array enables to dynamically create an antenna which is optimized for its antenna area or is effectively a dipole antenna, or which may be used as a capacitor. The dimensions of the antenna array can be readily modified such as to optimize the antenna array for specific frequencies. This directly enables the sensing arrangement to apply electromagnetic radiation based techniques, such as radar (for example frequency modulated continuous wave (FMCW) radar, the data of which may also be processed for Doppler analysis) or detecting high frequency disturbances (e.g. detection of thermal noise). At the same time, the sensing arrangement is suitable for performing capacity measurements, such as to determine material properties for example. Also, electric fields, magnetic fields or shifts in resonance frequency can be determined.

According to an embodiment of the invention, the sensor unit is arranged for operating the switchable interconnections for controlling operations of the antenna array in the plurality of operational modes. In this embodiment, the sensor unit controls the switching of interconnections for forming different types of antennas with the antenna array. This enables the centre unit to switch itself into different operational modes for measuring different properties or performing different measurement techniques. Moreover, by controlling the switchable interconnections, the sensor unit may also modify the antenna layout during measurement in a single operational mode. This enables the sensor unit to control a number of properties of the specific measurement technique applied, for example to modify the viewing angle of the sensor unit, or the area of focus of the sensor unit, or to perform a sweep of the area of focus.

According to a further embodiment of the invention, the patches spanning the first detection area are geometrically arranged in a matrix configuration. By arranging the patches in a matrix configuration in columns and rows, any two- dimensional geometric shape can be made.

According to a further embodiment of the present invention, the sensing unit is arranged for electrically interconnecting a group of the plurality of patches for each of the plurality of operational modes by means of the switchable interconnections, wherein the group of patches forms a geographic pattern in the first detection area associated with the operational mode. In particular, and according to a specific embodiment, the geographic pattern mentioned above is at least one of a group comprising two or more patches on a line, or three or more patches within or spanning an effective antenna area, said area being a polygon, a circle, an oval, or an arbitrarily shaped area. Any of these shapes provides particular properties to the antenna that renders it suitable for detecting various electrically measurable parameters, such as radiation, electric fields, capacitance and the like.

In respect of the above, it is noted that two or more patches on a line can be used for forming a dipole antenna, where three or more patches within or spanning an effective antenna array allows the creation of any arbitrarily shaped area. As may be known to the skilled reader, antenna designs exist in many different shapes for transmitting, receiving, or detecting all kinds of radiation or electric fields or specific properties.

According to a further specific embodiment of the invention, the sensor unit is arranged for electrically interconnecting at least a first group of patches and at least a second group of patches for forming a capacitor between the first and the second group for performing capacitance measurements using the first group of patches and the second group of patches. By creating at least two different groups of patches and forming a capacitor therebetween, a plurality of different measuring techniques either based on capacitance measurements (e.g. for acquiring information on the mass, volume, type of material, and/or other property of an object), or for creating a resonance circuit that detects shifts in resonance frequency, can be formed.

According to a further specific embodiment, the first and second group of patches each form a geometrically distinct area within the first detection area of the antenna array. For example two groups of interconnected patches may form adjacent or contiguous areas and capacitance or resonance measurements can be performed. Objects in the direct environment of the capacitor plates formed by the first and second group cause a change in the capacitance value of the capacitor or the resonance frequency of the circuit.

Moreover, the patches of the first group and the patches of the second group may also alternate each other such as to form a chequered pattern, or a pattern of alternating lines of patches that are associated with the first and second group respectively. This embodiment enables near field capacity measurements near the antenna array.

The sensing arrangement according to the present invention, in an embodiment thereof, may also comprise a further second detection area (preferably remote from the first detection area) for forming a capacitor between the first and second detection area. This enables capacity measurements between the patches of the first and second detection area. Within the range of several metres from the sensing arrangement, the presence of objects can be detected as well as material properties and properties such as mass, volume and the like. This is useful when the first and second detection area is, for example, placed on the side of a truck and its trailer. When the truck makes a right turn, any object which is located at a dangerous position in between the two detection areas (i.e. somewhere near the truck and its trailer) can be directly distinguished and an alarm signal can be generated in the cabin of the truck.

In any of the capacitance measurements described in association with the embodiments above, the sensor unit may be arranged for switching an induction unit parallel to the capacitor formed by the antenna array, for providing a resonance circuit arrangement. In this configuration, the capacitor formed by the antenna array and the induction unit together form an LC circuit, enabling resonance frequencies and deviations thereof to be determined.

The antenna array of the sensing arrangement of the present invention, in accordance with an embodiment, can also be used for providing a (controllable) dipole antenna, such as to detect detuning of the circuit as a result of shifts in the resonance frequency. In this embodiment, the geographic pattern is formed by a plurality of patches on a line. The input signal is provided to at least two centre patches of the plurality of patches on the line. Moreover, by making the number of interconnected patches of the plurality of patches selectable, the length of the dipole antenna can be controlled, and thereby the resonance frequency of the dipole antenna is controllable. An object within the presence of the dipole antenna causes a shift in the resonance frequency. In particular, by making the base resonance frequency controllable (by controlling the length of the dipole antenna) the dipole antenna can be used for distinguishing objects of different nature from each other. In accordance with a further embodiment of the present invention, the sensing arrangement further comprises a control circuit for controlling the sensor unit and analysing a sensor output signal of the sensor unit. The control circuit may also be used for switching the sensor unit into different operational modes. Additionally, by making an analysis of the sensor output signal of the sensor unit in different operational modes, the control signal enables the sensing arrangement to acquire detailed information on the type of object which is in the presence of the sensing arrangement. This enables to distinguish between for example living objects such as human beings or animals, and non-living objects. The control circuit may consecutively control the sensor unit to perform measurements using different electrical based sensing techniques, and analyse the data after receiving all the output signals.

According to a further embodiment of the invention the plurality of different electrical sensing techniques are elements of a group comprising frequency modulated continuous wave radar for measuring distance to an object, Doppler measurements for detecting motion of an object, high frequency capacity measurements using a resonance circuit arrangement for detecting detuning of a resonance frequency caused by an object, low frequency capacity measurements for detecting changes in a capacitance value caused by an object, direct current capacity measurements for detecting physical contact of an object with said sensor arrangement, dipole-human coupling measurements by detecting detuning of a resonance frequency of a dipole antenna, and detection of high frequency thermal noise for distinguishing objects by temperature.

In accordance with a second aspect, the invention is directed to a vehicle comprising a sensing arrangement as described hereinabove.

Brief description of the drawings

The invention will hereinbelow be described by means of various particular embodiments, with reference to the enclosed drawings, wherein:

figure 1 discloses a sensing arrangement according to the present invention;

figures 2A-2E disclose various switching arrangements for interconnecting patches of the antenna area forming geographic patterns;

figure 3 schematically shows the principle of interconnecting the patterns with switchable interconnection;

figure 4 illustrates schematically one of the sensing techniques in use.

Detailed description of embodiments

Figure 1 discloses a sensing arrangement 1 according to the present invention. The sensing arrangement 1 comprises a sensor unit 2 and a controller unit 3. The sensor unit 2 is arranged for being used in a plurality of operational modes, wherein in each of the modes one or more electrically measurable parameters can be sensed by the sensor unit 2 by using electrically based sensing techniques.

The microprocessor unit 6 controls operation of the sensor unit 2 in each of the plurality of operational modes. Microprocessor unit 6 does this by controlling operation of sensor circuitry 7 and by controlling microprocessor unit 12 that determines operation of the antenna unit 8 of the sensor unit.

Antenna unit 8 comprises a plurality of antenna patches such as patch 17 which are interconnected by means of switchable interconnections such as interconnection 18. In the present example, antenna unit 8 comprises two remote detection areas schematically indicated by 15 and 16 formed by these patches. The number of detection areas is however arbitrarily chosen in this example and may vary from a single detection area to as many detection areas as desired to achieve the specific goals of the application wherein the invention is used. However, since the present sensing arrangement assumes use of the sensing arrangement on a truck with a trailer, the sensing arrangement comprises two detection areas 15 and 16 that are used individually and in combination in order on one side of the truck-trailer combination, to determine the required parameters. It will be understood that detection areas may be located on both sides of the truck-trailer combination, and cooperation is to certain extent desired between the detection areas on either one side of the truck: the detection areas on the left side of the truck operate individually and in cooperation and the detection areas on the right side of the truck operate individually and in combination.

Microprocessor 12 of antenna unit 8 controls the switching circuitry 21 and 22 of detection areas 15 and 16 respectively. The switching circuitry 21 of detection area 15 controls the switching of each individual interconnection, such as interconnection 18, of detection area 15. Similarly, the switching circuitry 22 of detection area 16 controls the switchable interconnection of detection area 16. If microprocessor unit 6 of sensor unit 2 switches operation of sensor unit 2 (for example) frequency modulated continuous wave (FMCW) radar, microprocessor unit 6 communicates this to microprocessor unit 12 of the antenna unit 8 and at the same time controls the sensor circuitry 7 to operate in the desired operational mode. Upon receiving the instruction from microprocessor unit 6, microprocessor unit 12 controls the switching circuitry 21 of detection area 15, which switches the detection area 15 such as to interconnect the patches of detection area 15 into a geometrical pattern for forming a suitable antenna configuration for performing the FMCW rate measurements. The sensor circuitry 7, which is operated in the FMCW operational mode, provides the required frequency sweep signal which is typical for FMCW radar. The signal provided by sensor circuitry 7 is received by I/O port 11 of antenna unit 8, which passes on the signal to patches 25 and 26 of detection area 15 for transmission of the frequency sweep signal through the antenna configuration. The return signal is passed on back to the sensor circuitry 7 through I/O port 11. Microprocessor unit 6 may perform the necessary operation for providing a meaningful sensor output to controller unit 3 of the sensing arrangement 1.

In a further operational mode, when the sensor unit 2 is for example operated such as to perform capacitance measurements between detection area 15 and detection area 16, all patches of each detection area 15, 16 may be interconnected for forming capacitor plates. An input signal is then provided through input output port (I/O port) 11 to both detection areas 15 and 16.

The function of the controller unit 3 of the sensing arrangement is to provide instructions to the microprocessor unit 6 for operating the sensor unit 2 in a certain operational mode, and to receive the sensor up signal from microprocessor unit 6. With the sensor output signal received from microprocessor unit 6, the controller unit performs a required analysis for making an assessment on whether or not objects are present in the proximity of the detection areas, and in order to distinguish whether or not these objects are living objects or non living objects. Controller unit 3, based on this analysis, provides a suitable alarm signal to the internal CAN network 29 of the vehicle, which passes this signal on to an output unit such as audible alarm 30 in th e cabin of the truck, or an indication light.

Figures 2A-2E disclose various antenna configurations that can be created by suitably switching the switchable interconnections between the patches of the antenna unit. Although the figures 2A-2E disclose specific examples of geographic patterns that can be formed by suitably interconnecting the patches, it will be understood that any arbitrary geometric pattern can be formed and the examples of figures 2A-2E are not to be considered as limiting on the scope of the invention.

Figure 2A discloses a disk shaped antenna configuration that may be used for example as a suitable antenna for performing FMCW radar measurement, as well as Doppler radar. In FMCW radar, a frequency sweep signal is transmitted by the antenna configuration, and a return signal is received after reflection thereof by an object near the antenna. By analysing the frequency shift between the transmitted signal and the received signal, the distance between the antenna and the object can be determined. The angle of view of the FMCW method can be influenced in various ways, amongst others by modifying the radius of the antenna configuration. In this respect, the skilled person may appreciate that an antenna configuration having a small radius provides a large viewing angle with less accuracy, while an antenna configuration with a large radius provides a small viewing angel with high accuracy. This is reflected by figures 2A and 2B. In figure 2A, the open blank patches such as patch 34 illustrate the patches that switched off (not interconnected), and that are not used in the antenna configuration. The black patches such as patch 35 are the active (interconnected) patches of the antenna configuration.

In figure 2A, the antenna configuration provided by the geometric pattern has a relatively large effective area, and thereby a relatively small viewing angle providing an accurate distance measurement. On the other hand, in figure 2B, the active patches 39 of the antenna area form a relatively small disk shaped antenna configuration with a small effective area and therefor a relatively large viewing angle.

Figures 2C and 2D illustrate interconnection of the patches of the antenna configuration such as to form dipole antennas of different kinds. The dipole antennas illustrated in figure 2C, formed by the active patches such as patch 41 form a dipole antenna which is fed centrally. The resonance frequency is determined by the length of the antenna formed, i.e. the number of aligned interconnected patches. This length determines the wave length of standing waves within the dipole antenna, and thereby their resonance frequency.

In figure 2D, the length of the dipole antenna is half the length of the dipole antenna in figure 2C. Therefor, the wavelength of standing waves in the dipole antenna of figure 2D (patches 46) is half that of the dipole antenna illustrated in figure 2C. As a result, the resonance frequency of the dipole antenna of figure 2D is twice as high as the resonance frequency of the dipole antenna disclosed in figure 2C.

For completeness, and as will be understood by the skilled person, if the antenna area is to be used as a capacitor plate, all the patches may be interconnected together such as to form one large plate. This is illustrated by the patches 48 of figure 2E. Plates however may also be formed by forming multiple individual interconnected patch areas (not shown).

Figure 3 illustrates the principle of switching interconnections between the patches of the antenna array. In figure 3, unit 50 is the switching circuitry of the antenna array which provides switching signals to the transistor units 61, 62, 63 and 64. Each transistor unit may be operated individually by the switching circuitry 50. By operating the transistors 61-64, the patches 52, 53, 54, 55, 57 and 58 can be interconnected. In the present example, a feed signal (input signal) is provided through input 67 of the antenna array to the centre patches 54 and 55 of the dipole antenna formed in figure 3. It will be understood that the feed signal may be provided to different patches of the antenna array by choice. In that case, it will be understood that the antenna array additionally requires circuitry to provide the input signal to the selected desired patch of the antenna array. The specific location of the patches receiving the input signal determines behaviour of the antenna configuration, and may therefor be used advantageously in the measurement process.

Figure 4 discloses an application of the present invention wherein a truck 70 with trailer 71 and cabin 72 comprises a sensing arrangement having two remotely distinct detection areas 75 and 76. If the truck 70 makes a right turn, by using the detection areas 75 and 76 as capacitor plates, capacitance measurements may be performed that provide insight in a number of measurable properties and parameters indicative for the object 78 between the two plates 75 and 76. This enables distinguishing between living beings (such as pedestrian 78) and non living objects.

The above described embodiments are provided as an example only, and the skilled person will recognise that the teachings of this document can be applied in many different ways. The antenna array in accordance with the invention consists of an array of electrically conducting patches, which are galvanically interconnected through switches to form an antenna or multiple antenna elements. The feeding arrangement is switched in accordance with these so formed antenna elements. Thus, the antenna elements and combinations thereof can be configured for any desired frequency band.

The discrimination between living beings and objects is accomplished through combining different sensing techniques simultaneously or sequentially for different ranges. For example, if at a certain distance a temperature rise is detected with a small chance of being caused by a human (disturbance by cars, sun, etcetera), and the same time a velocity is measured of a few metres per hour with also a small chance of being caused by a human (could be caused by a slowly moving car), and at the same time a dielectric constant of 80 is detected with again a small chance of being caused by a human (could be a wet object), then all the small chances combined will give a high to very high chance of the disturbance being caused by a human. The arrangements of the invention uses this detection technique to determine whether or not a human being is present nearby, e.g. in a dangerous location relative to, the vehicle.

In the above detailed description, for purposes of explanation and not limitation, example embodiments disclosing specific details were set forth in order to provide a thorough understanding of embodiments according to the present teachings. However, it will be apparent to one having ordinary skill in the art having had the benefit of the present disclosure that other embodiments according to the present teachings that depart from the specific details disclosed herein remain within the scope of the appended claims. Moreover, descriptions of well-known apparatuses and methods may be omitted so as to not obscure the description of the example embodiments. Such methods and apparatuses are clearly within the scope of the present invention, as defined by the appended claims.

CLAIMS

1. Living-being proximity sensing arrangement for a vehicle, said arrangement being arranged for distinguishing proximity of a human or animal body from proximity of a non-living object, said sensor arrangement comprising a sensor unit which comprises an antenna array, wherein said antenna array is operable in a plurality of operational modes for enabling use of said antenna array for performing at least one of a plurality of different electrical sensing techniques in each of said modes, wherein said antenna array comprises:

means for providing an antenna input signal to said antenna array and means for presenting an antenna output signal from said antenna array;

a plurality of patches spanning a first detection area of said antenna; and

a plurality of interconnections between said patches, wherein said interconnections are switchable for enabling connection and disconnection of said switchable electrical connections between said patches for enabling operation of said antenna in each of said plurality of operational modes.

2. Sensing arrangement according to claim 1, wherein said sensor unit is arranged for operating said switchable interconnections for controlling operation of said antenna array in said plurality of operational modes.

3. Sensing arrangement according to any of the previous claims, wherein said patches spanning said first detection area are geometrically arranged in a matrix configuration.

4. Sensing arrangement according to any of the previous claims, wherein said sensor unit is arranged for electrically interconnecting a group of said plurality of patches for each of said plurality of operational modes by means of said switchable interconnections, said group of patches forming a geographic pattern in said first detection area associated with said operational mode.

5. Sensing arrangement according to claim 4, wherein said geographic pattern is at least one of a group comprising two or more patches on a line, or three or more patches within or spanning an effective antenna area, said area being a polygon, a circle, an oval, or an arbitrarily shaped area.

6. Sensing arrangement according to any of the claims 4 or 5, wherein said sensor unit is arranged for electrically interconnecting at least a first group of

patches and at least a second group of patches, for forming a capacitor between said first and second group for performing capacitance measurements using first group of patches and said second group of patches.

7. Sensing arrangement according to claim 6, as dependent on claim 3, wherein said first and said second group of patches each form a geometrically distinct area within said first detection area of said antenna array.

8. Sensing arrangement according to claim 6, as dependent on claim 3, wherein said patches of said first group and said patches of said second group alternate each other such as to form a chequered pattern or a pattern of alternating lines of patches associated with the first and second group respectively.

9. Sensing arrangement according to any of the previous claims, wherein said antenna array further comprises a second detection area for forming a capacitor between said first detection area and said second detection area for performing capacitance measurements between patches of said first and second detection area.

10. Sensing arrangement according to any of the claims 6-9, wherein said sensor unit is arranged for switching an inductor unit parallel with said capacitor formed by said antenna array for providing a resonance circuit arrangement.

11. Sensing arrangement according to any of the previous claims, wherein said means for providing said input signal are arranged for providing said input signal to one or more of said patches in a selectable manner.

12. Sensing arrangement according to claim 11, as far as dependent on claim 4, wherein said geographic pattern is formed by a plurality of patches on a line, wherein said input signal is provided to at least two center patches of said plurality of patches on a line for forming a dipole antenna.

13. Sensing arrangement according to claim 12, wherein the number of interconnected patches of said plurality of patches on a line is selectable by said sensor unit for controlling the resonance frequency of said dipole antenna.

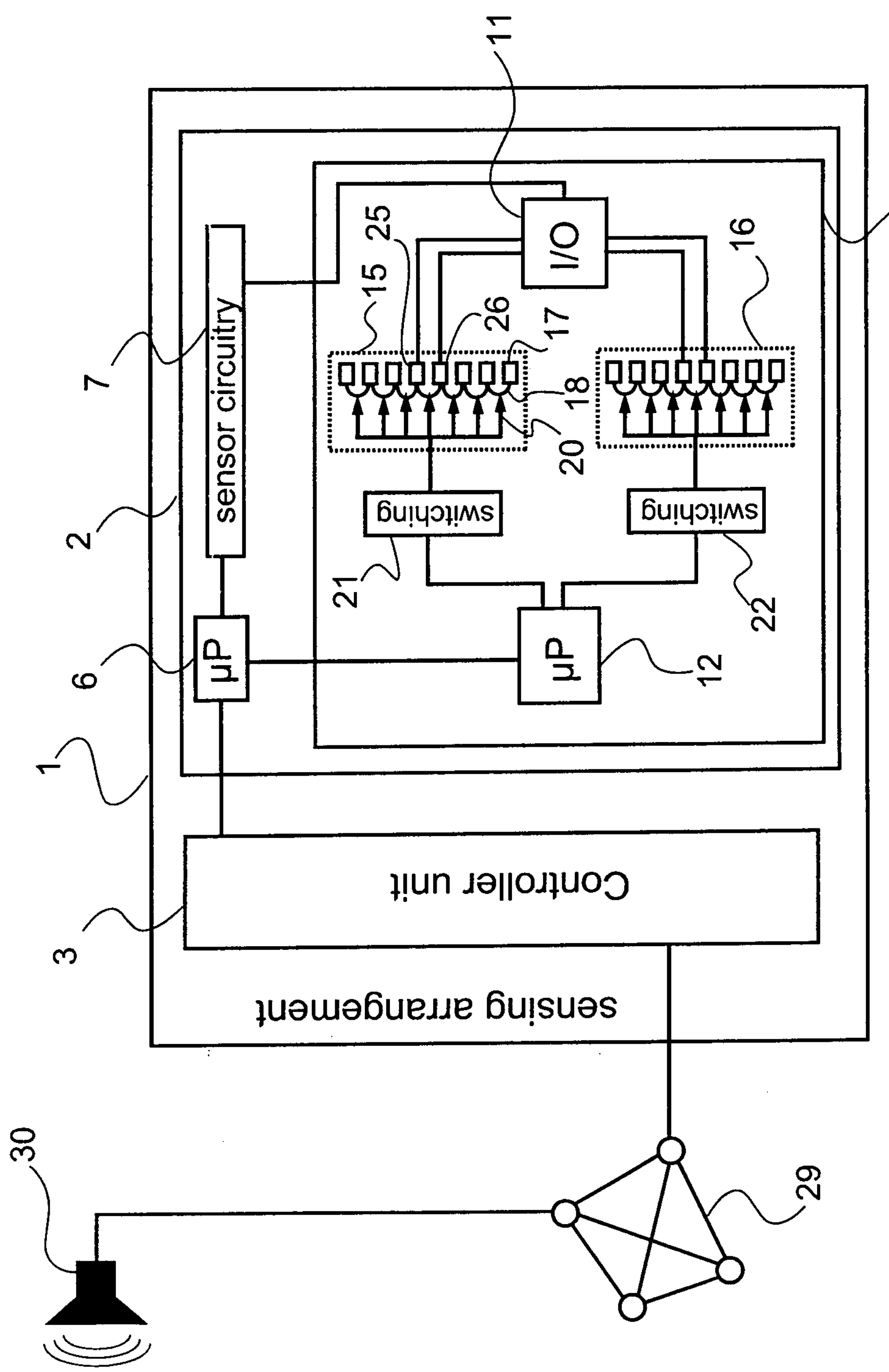
14. Sensing arrangement according to any of the previous claims, further comprising a control circuit for controlling said sensor unit and analysing a sensor output signal of said sensor unit.

15. Sensing arrangement according to claim 14, wherein said control circuit is arranged for operating said sensor unit and said antenna unit subsequently in a plurality of said operational modes.

16. Sensor arrangement according to any of the claims 14 and 15, wherein said control circuit is arranged for distinguishing a human or animal body from non-living objects by using at least two of said plurality of different electrical sensing techniques.

17. Sensing arrangement according to any of the previous claims, wherein said plurality of different electrical sensing techniques are elements of a group comprising frequency modulated continuous wave radar for measuring distance to an object, Doppler measurements for detecting motion of an object, high frequency capacity measurements using a resonance circuit arrangement for detecting detuning of a resonance frequency caused by an object, low frequency capacity measurements for detecting changes in a capacitance value caused by an object, direct current capacity measurements for detecting physical contact of an object with said sensor arrangement, dipole-human coupling measurements by detecting detuning of a resonance frequency of a dipole antenna, and detection of high frequency thermal noise for distinguishing objects by temperature.

18. Vehicle comprising a sensor arrangement according to any of the previous claims for distinguishing proximity of a human or animal body from proximity of a non-living object.



sensing arrangement
Controller unit
sensor circuitry
μP
μP
I/O
switching
switching
1
2
3
6
7
8
11
12
15
16
17
18
20
21
22
25
26
29
30

Fig. 1

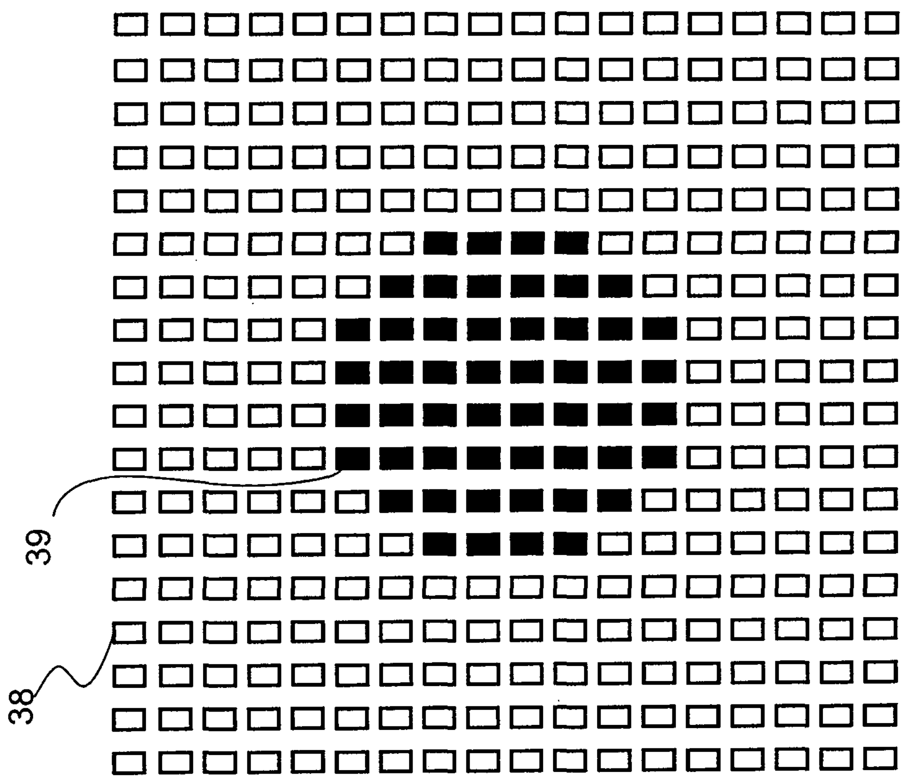


Fig. 2B

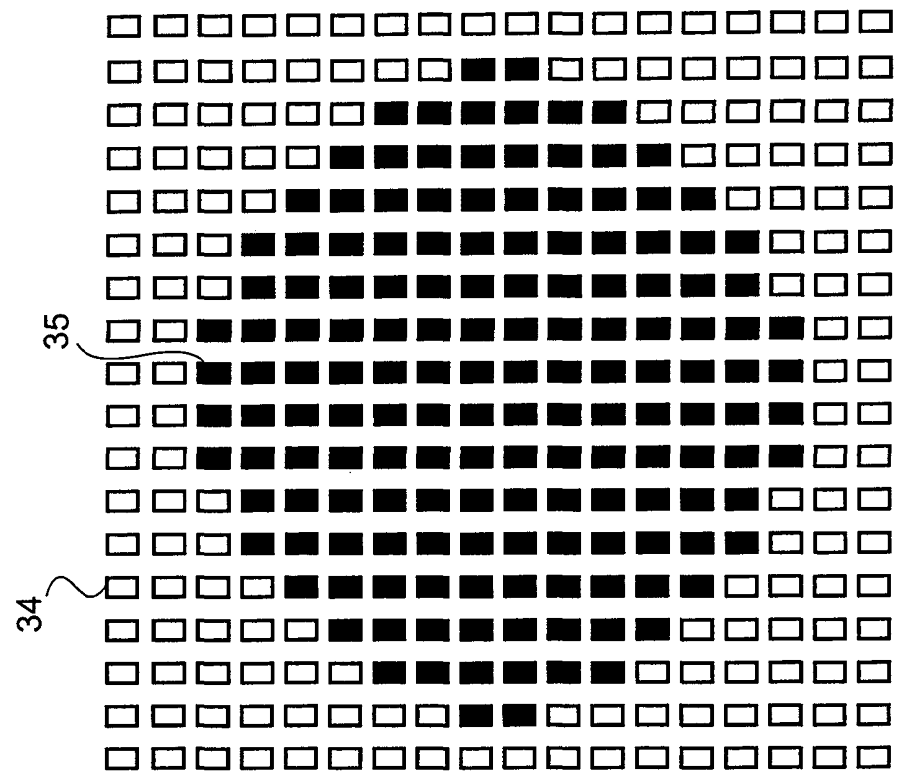


Fig. 2A

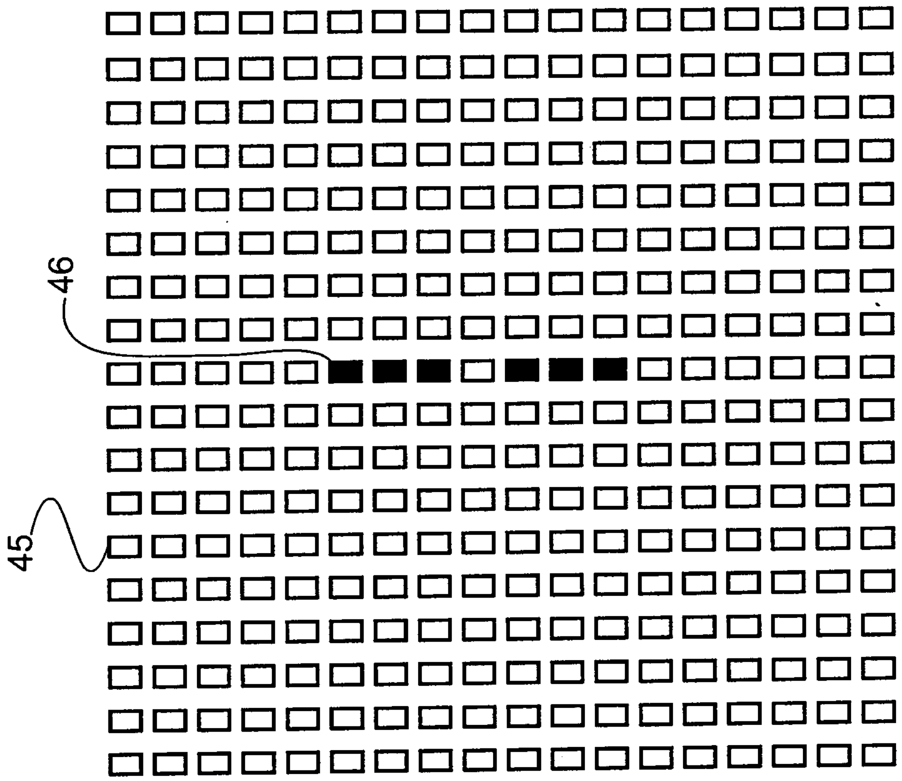


Fig. 2D

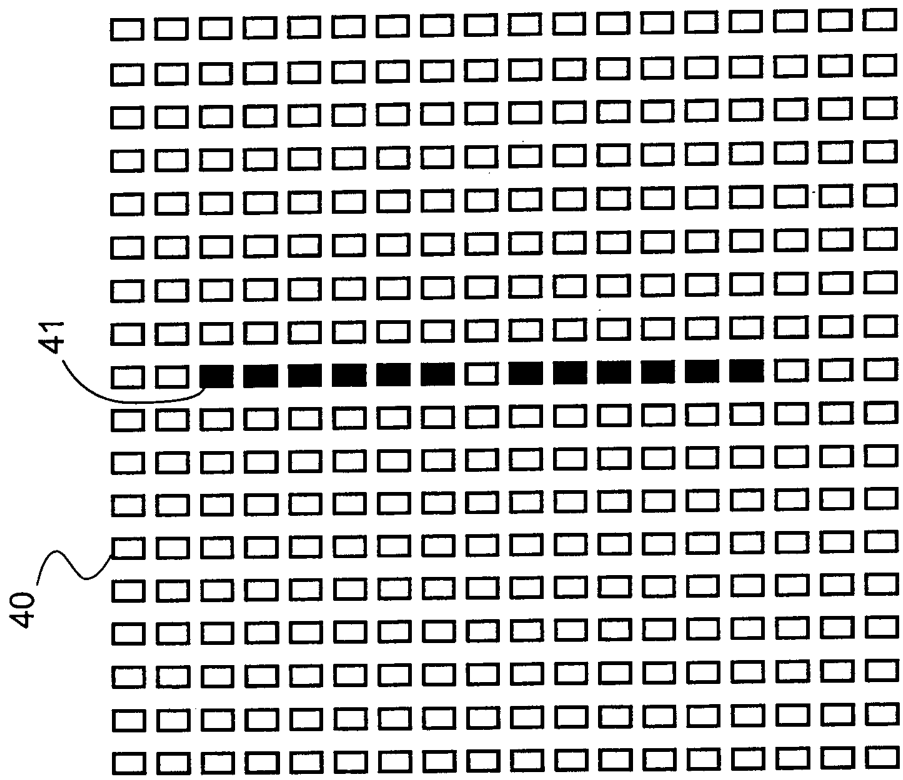


Fig. 2C

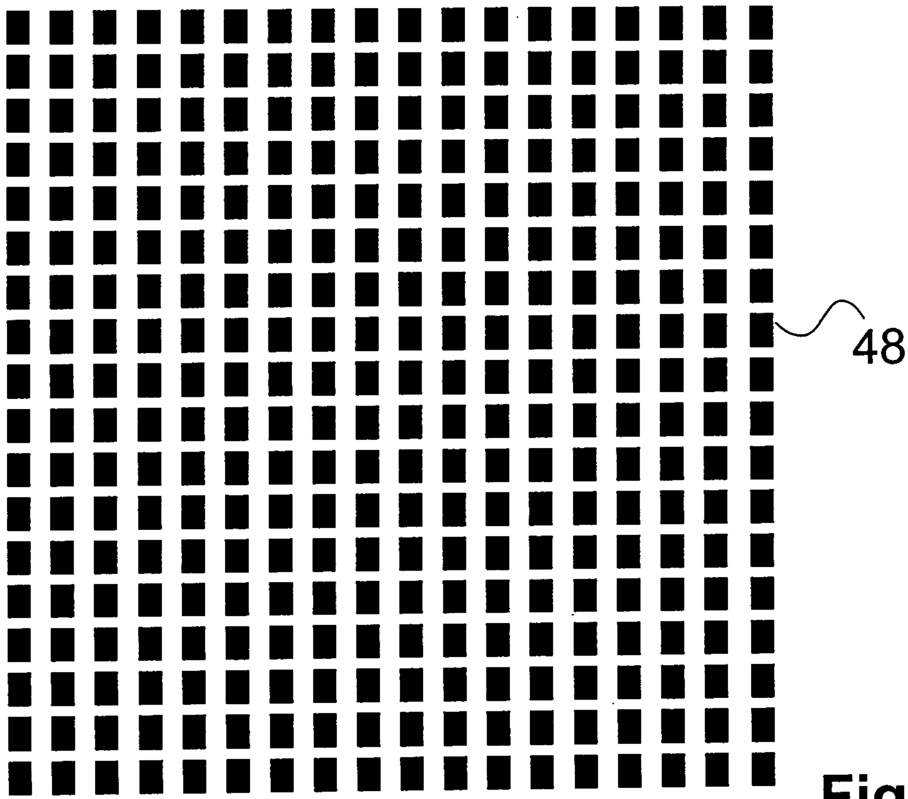


Fig. 2E

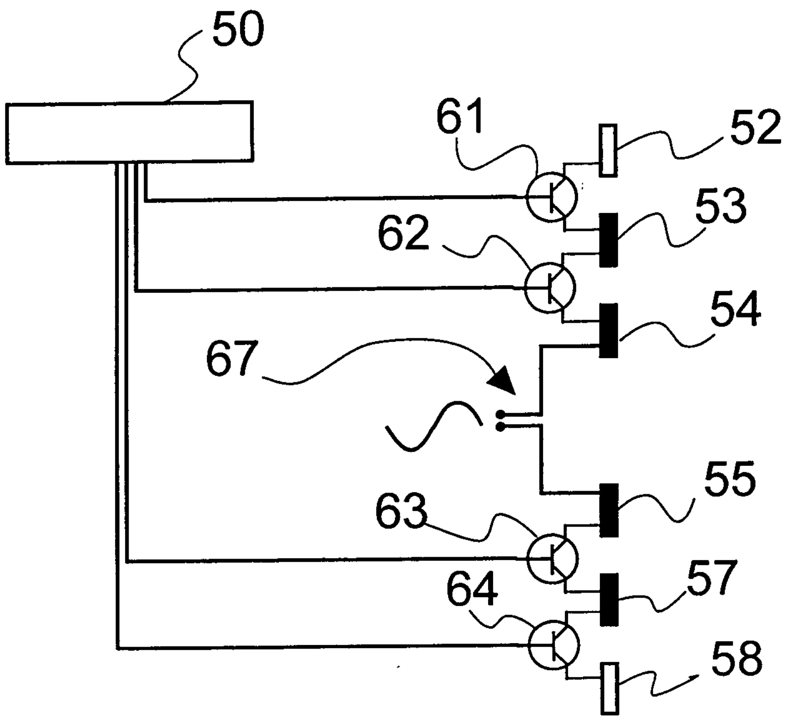


Fig. 3

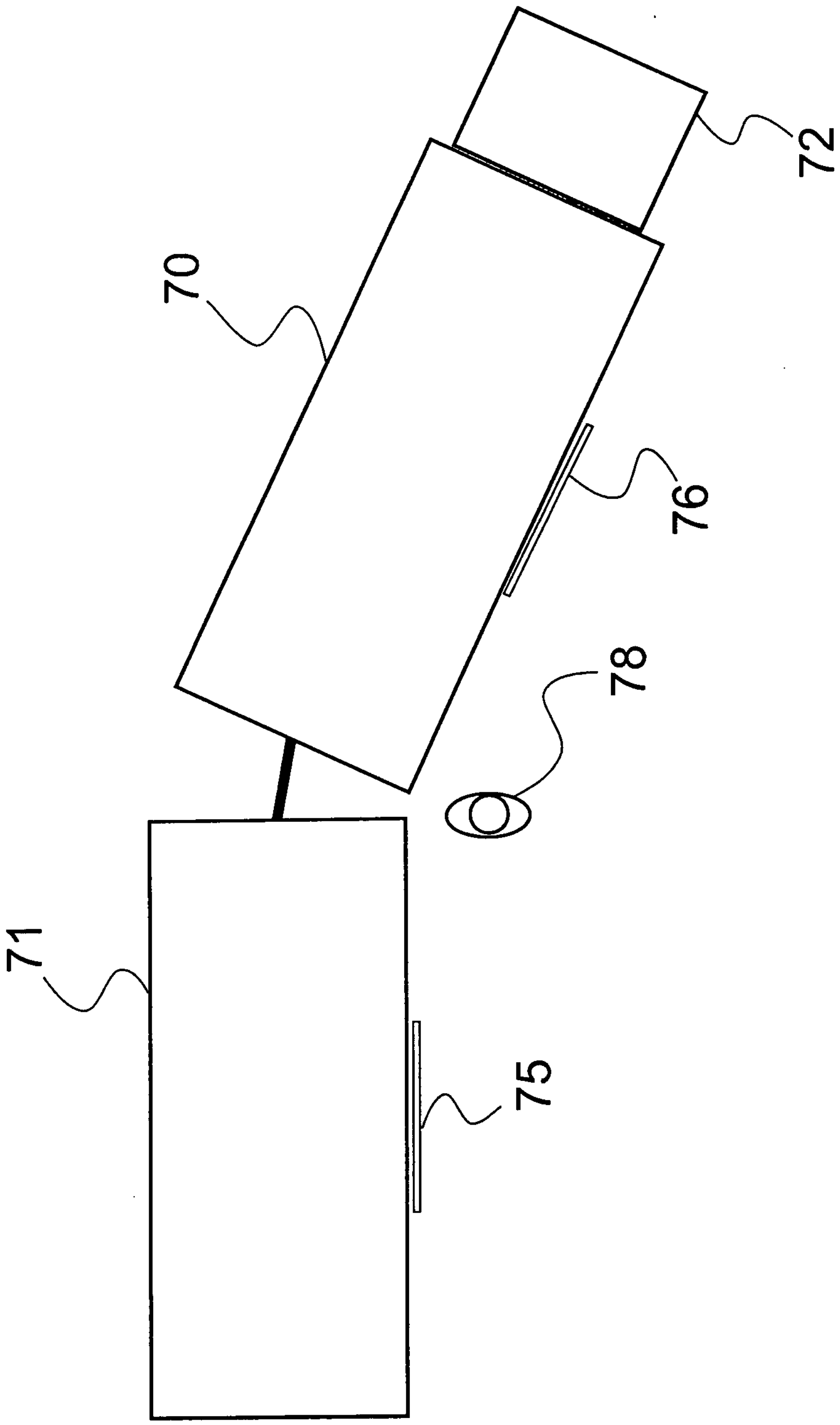


Fig. 4

INTERNATIONAL SEARCH REPORT

International application No
PCT/NL2010/000054

A. CLASSIFICATION OF SUBJECT MATTER
INV. G01S7/41 H01Q3/24
ADD. G01S13/93 H03K17/955

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
G01S H01Q H03K

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

EPO-Internal

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X Y	US 2005/128132 A1 (ZILLER THOMAS [DE] ET AL) 16 June 2005 (2005-06-16) * abstract; figures 1,3-6 paragraph [0044] - paragraph [0064]	1-5,14, 15 6-13, 16-18
X	US 2003/112172 A1 (SHINODA HIROSHI [JP] ET AL) 19 June 2003 (2003-06-19) * abstract; figure 1 paragraph [0027] - paragraph [0030]	1,14,15
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[X] Further documents are listed in the continuation of Box C.

[X] See patent family annex.

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Date of the actual completion of the international search	Date of mailing of the international search report
23 June 2010	02/07/2010

Name and mailing address of the ISA/	Authorized officer
European Patent Office, P.B. 5818 Patentlaan 2 NL – 2280 HV Rijswijk Tel. (+31-70) 340-2040, Fax: (+31-70) 340-3016	Niemeijer, Reint

INTERNATIONAL SEARCH REPORT

International application No
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C(Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

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